Microbasins and Missions: Hydrogeology and History Converge at Tumacacori National Historical Park

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Intermountain Region
Tucson, Arizona
with
Philip Halpenny and
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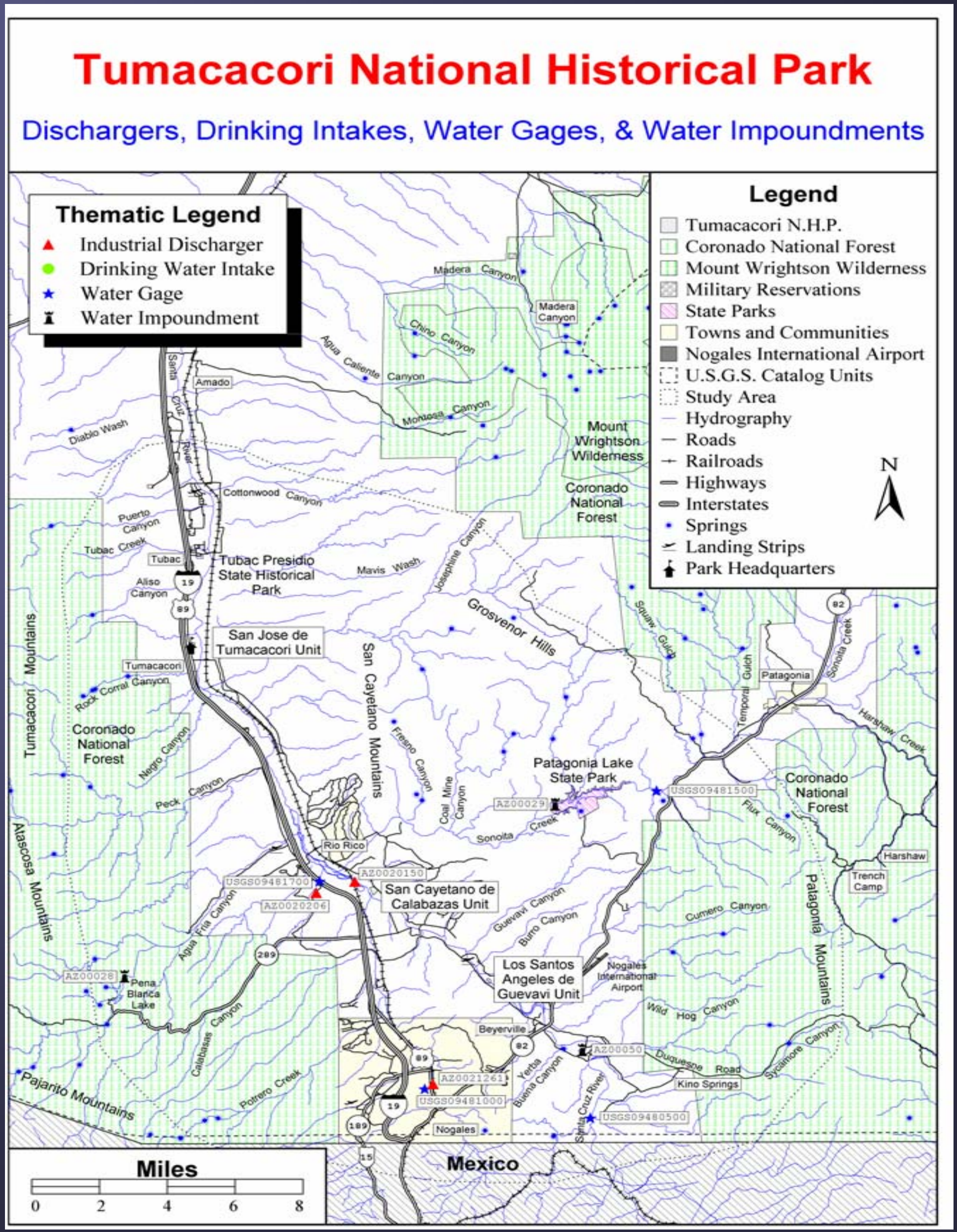
Tumacacori National Historical Park



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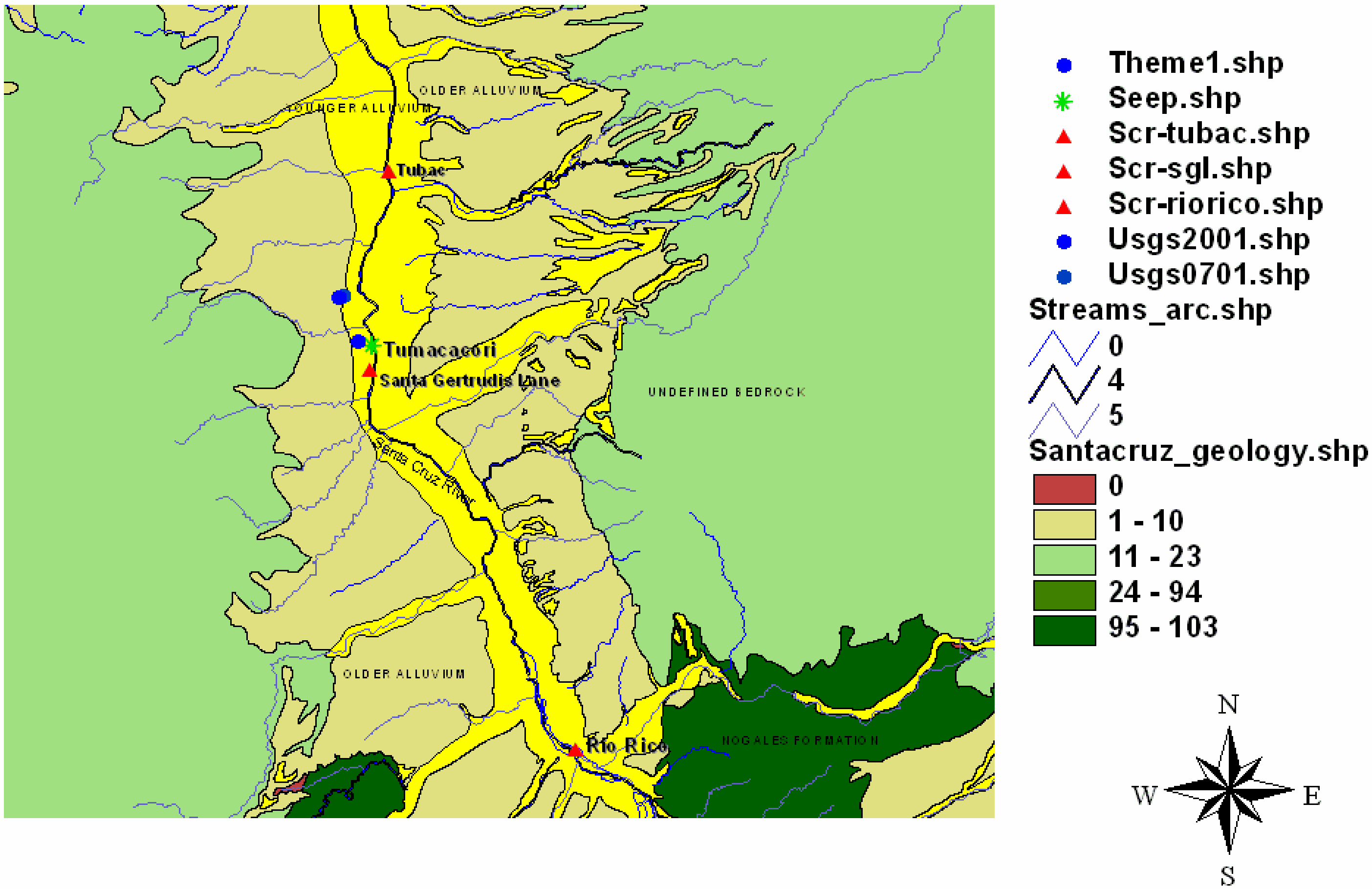
Geological units and sample locations



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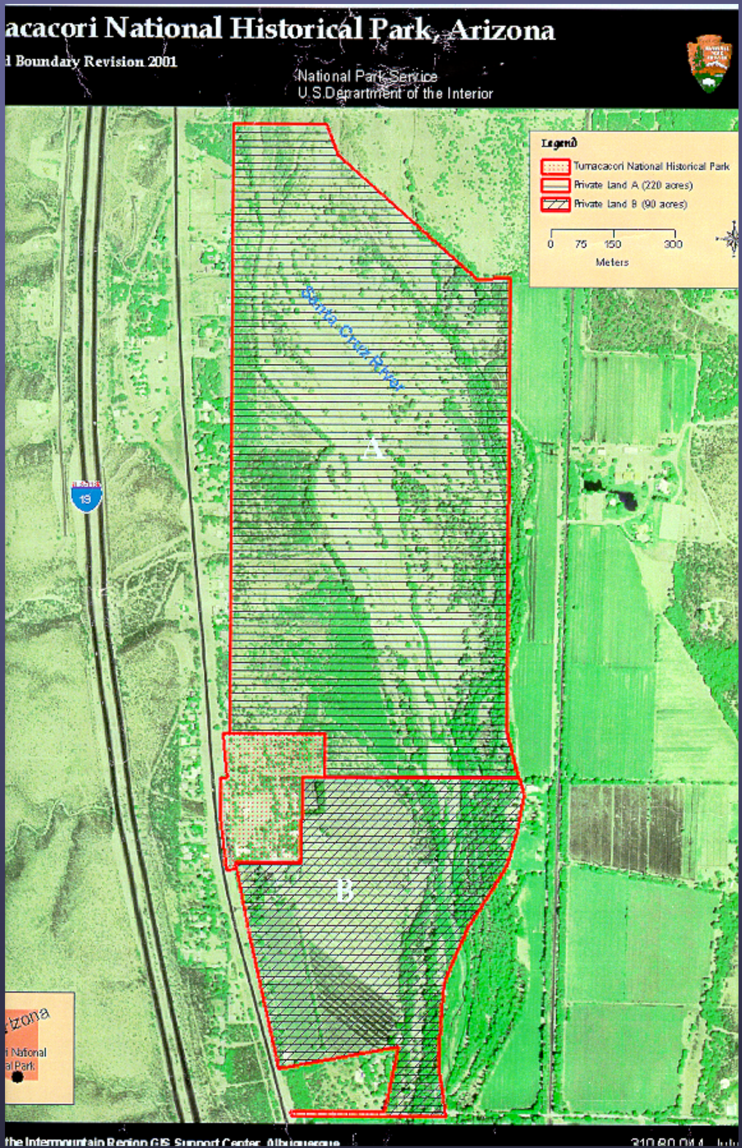

Upper Santa Cruz River

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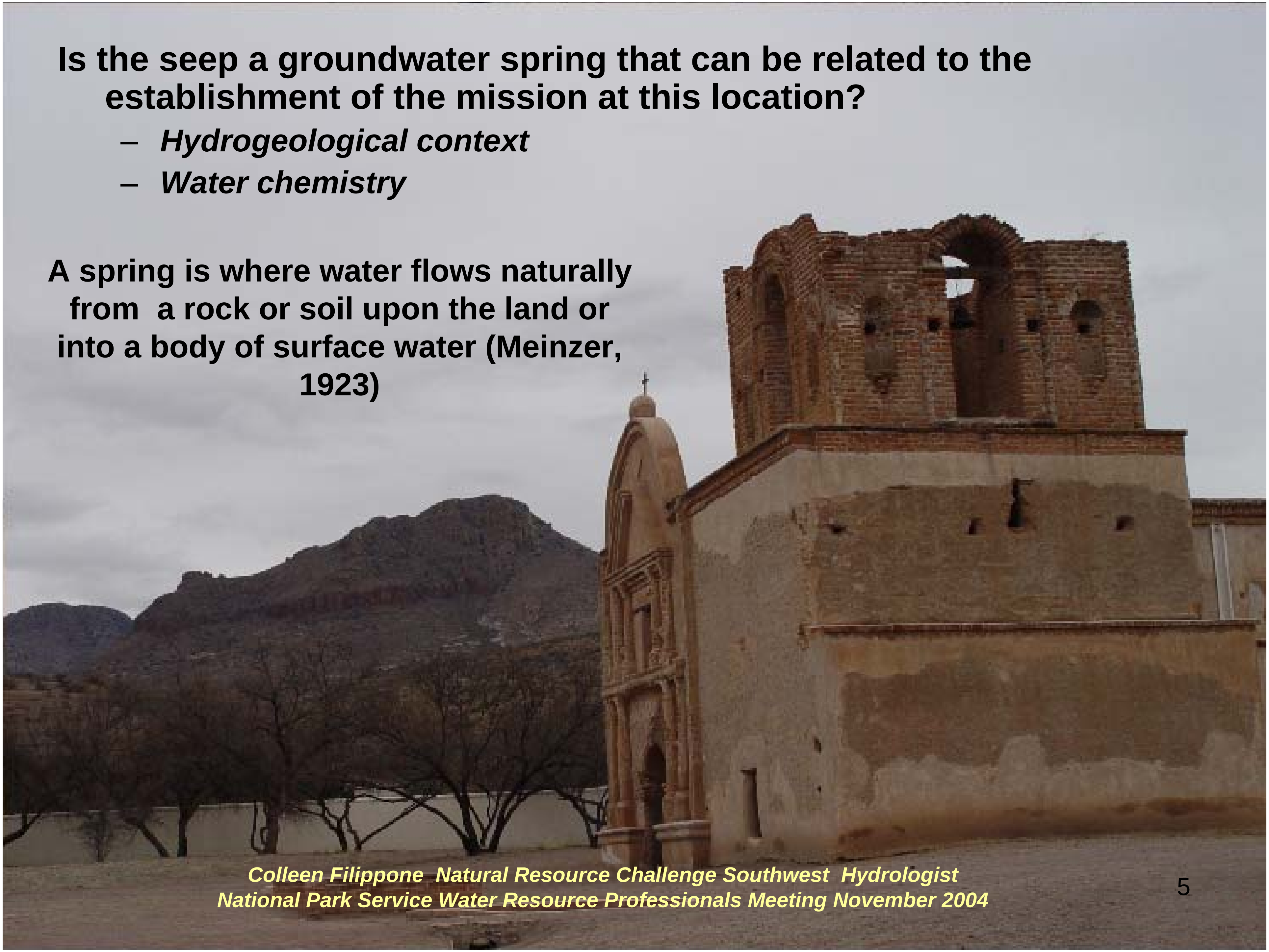
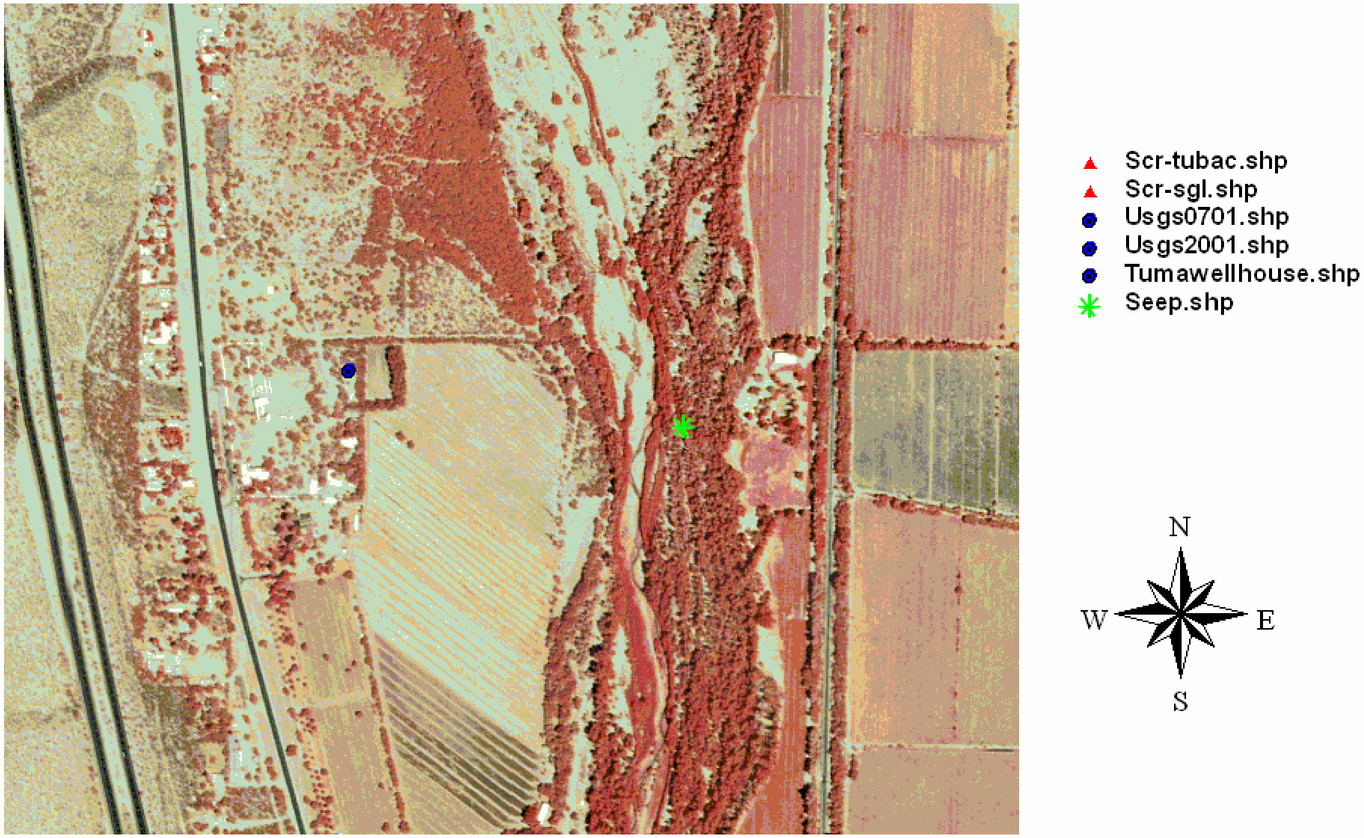
Is the seep a groundwater spring that can be related to the establishment of the mission at this location?

- ***Hydrogeological context***
- ***Water chemistry***

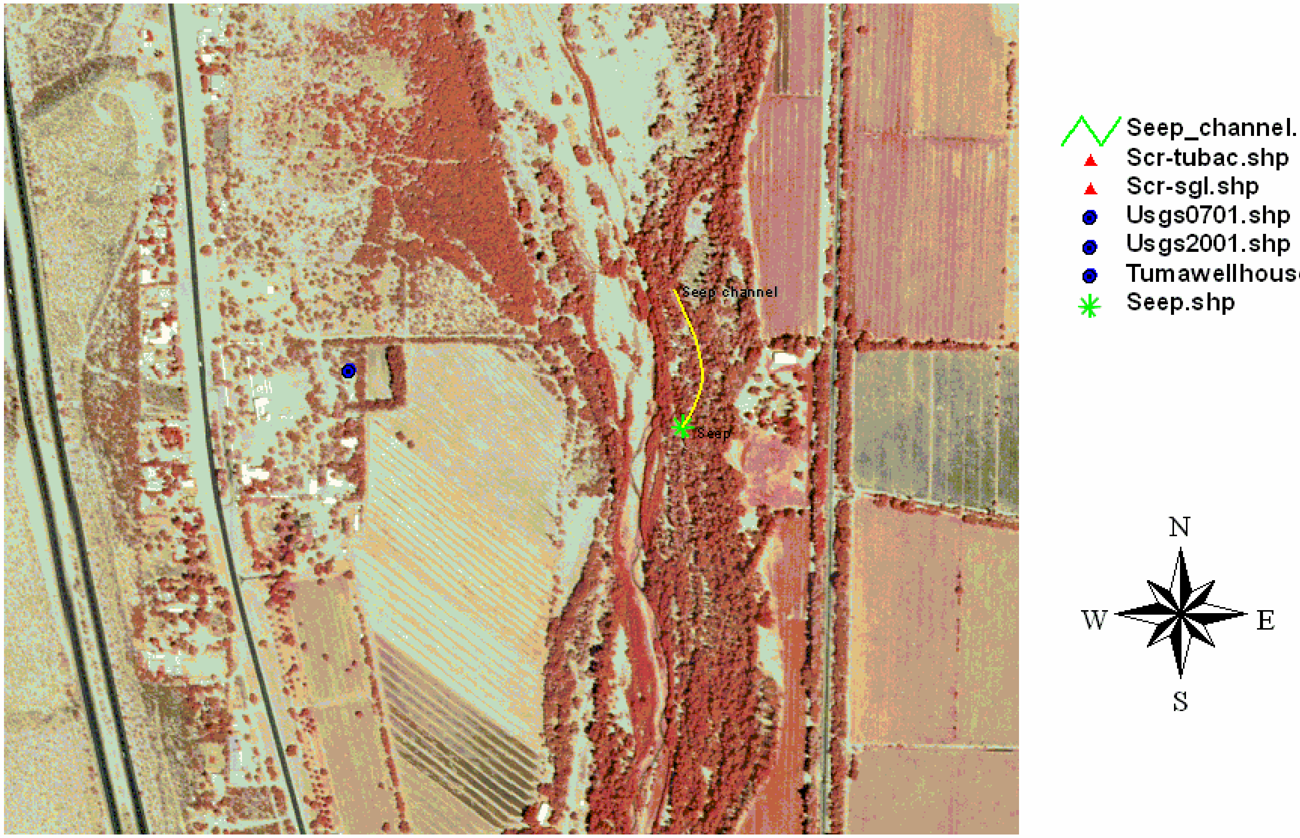
A spring is where water flows naturally from a rock or soil upon the land or into a body of surface water (Meinzer, 1923)



Seep location



Seep and cutoff channel



10/20/1983 1:12,000

1/20/1993 1:15,000

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Cutoff channel

Head of channel

LM: the abandoned cutoff channel intersects and drains the local water table. There is no spring.

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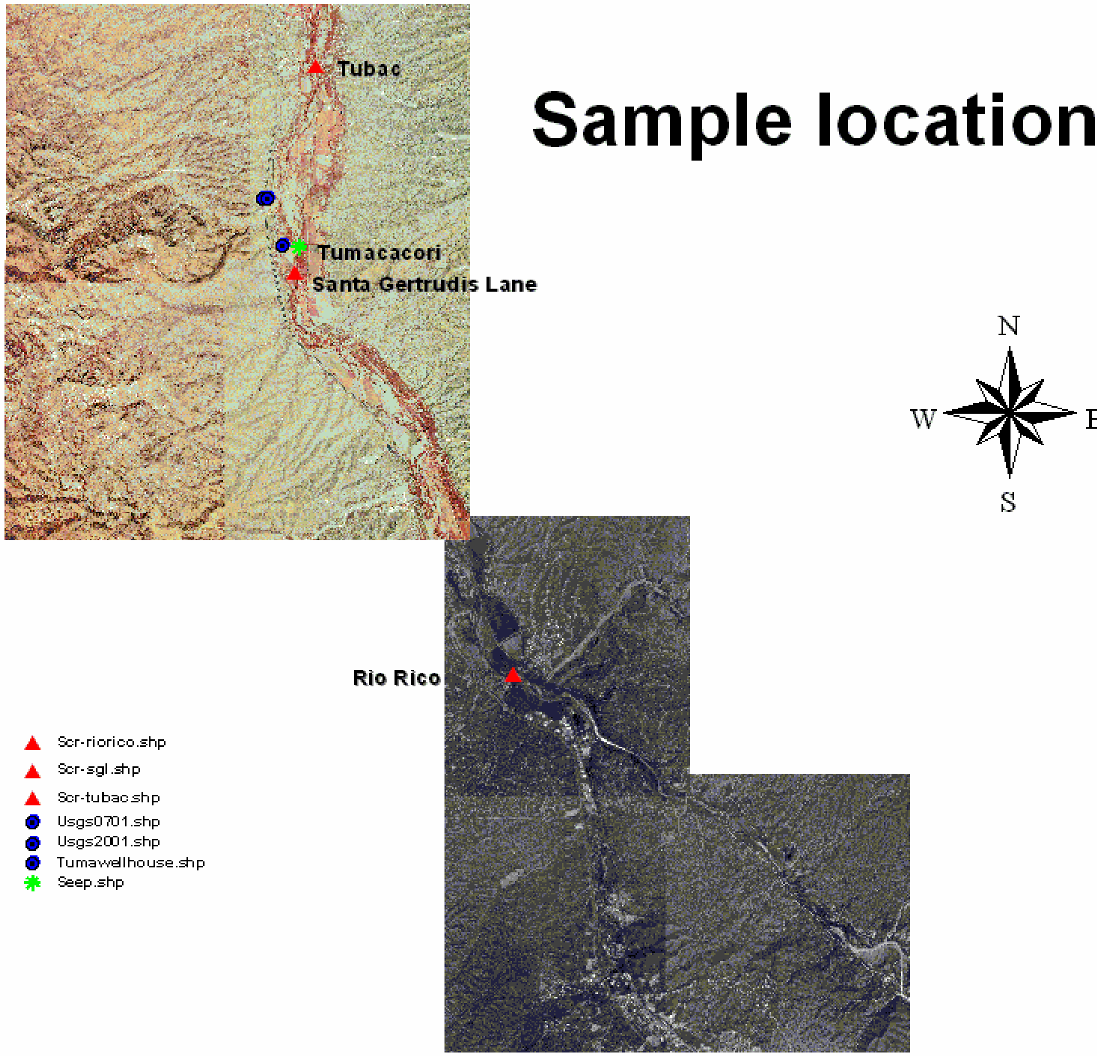
Sample locations

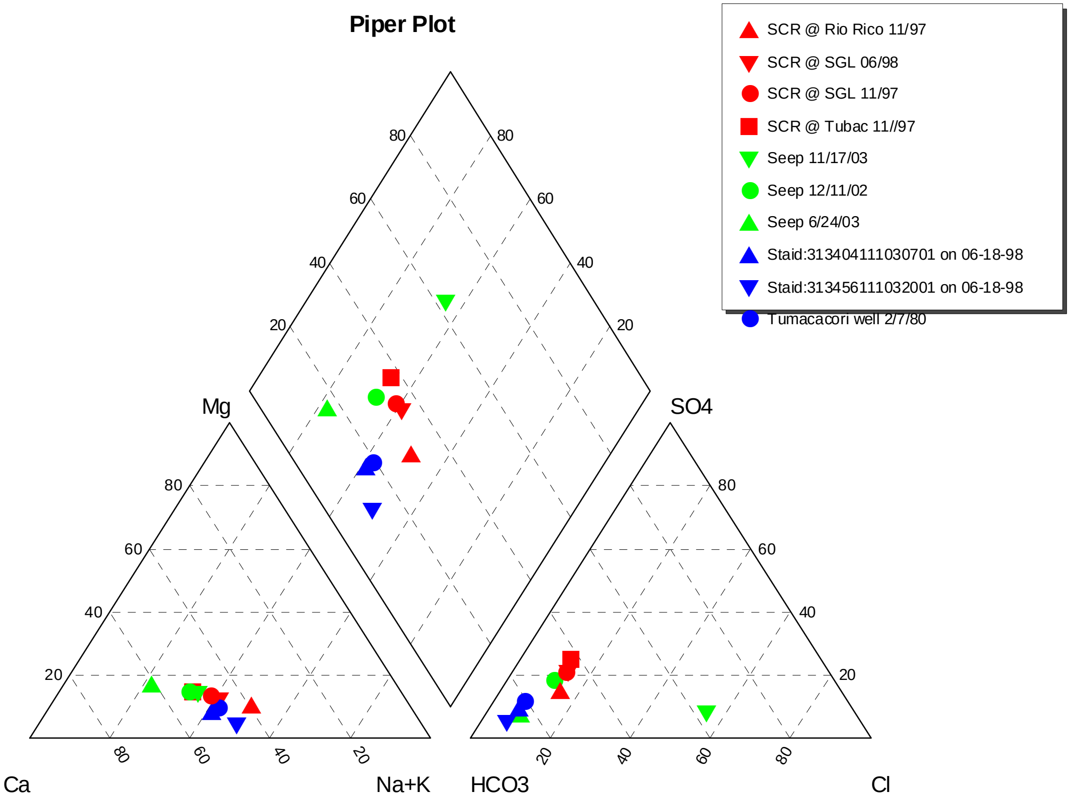


Level 1 Baseline Water Quality Inventory

Sampling spring/seep water –
December 2002
Sample 1

- **dissolved oxygen = 4 mg/L**

Sampling source water
June 2003 Sample 2
November 2003 Sample 3
•DO = 0.3 mg/L (June)



DESCRIPTION:	Water-quality Santa Cruz River, Tumacacori seep and nearby wells		
National Park Service Natural Resource Challenge Intermountain Region	PARK: Tumacacori National Historical Park	STUDY:	Tumacacori seep
	REGION: Intermountain Region	DATE:	November 2004

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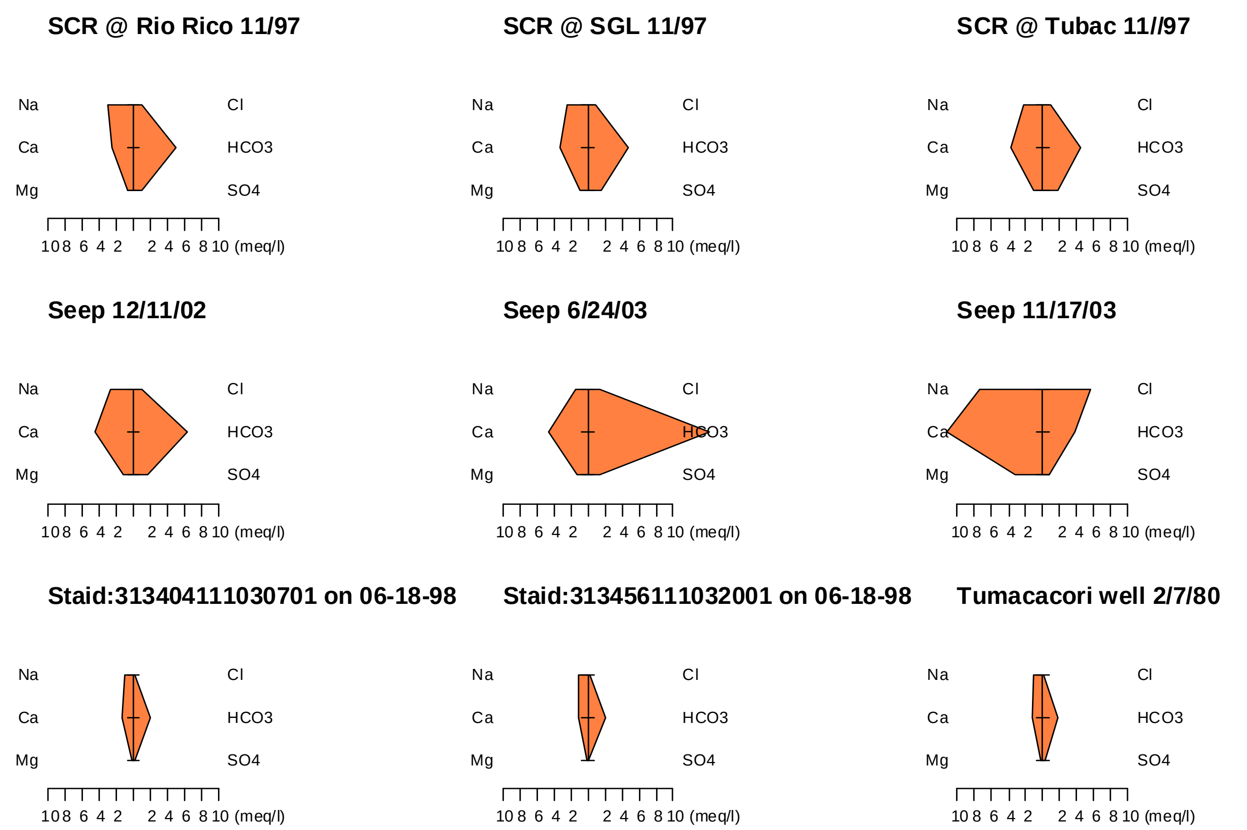

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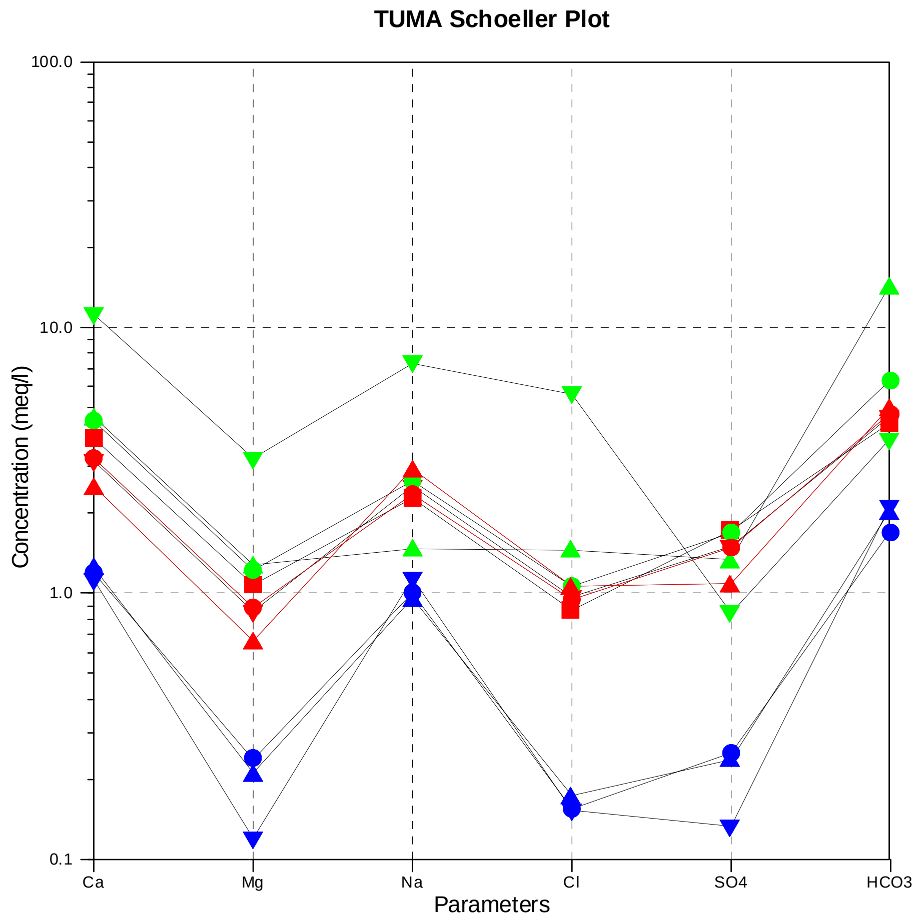

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Redox Chemistry of Hydric Soils

Telltale signs of anaerobic conditions
- **-accumulation of organic carbon**
- **-production of H_2S and CH_4**

OXIDATION of organic compounds releases electrons and hydrogen atoms (pH decreases)
- **-microbial respiration**
- **-no respiration, no redox reactions**

REDUCTION of electron acceptors (pH reduced in alkaline soils)
- **-O2 always first**
- **-NO3 - (N2)**
- **-MnO2 (Mn2+,4+)**
- **-Fe(OH)3 (Fe2+,3+)**
- **-SO42- (H2S)**
- **-CO2 (CH4)**

Idealized sequence of chemical transformations in saturated soils under anaerobic conditions. (Mitsch and Gosselink, 2000)

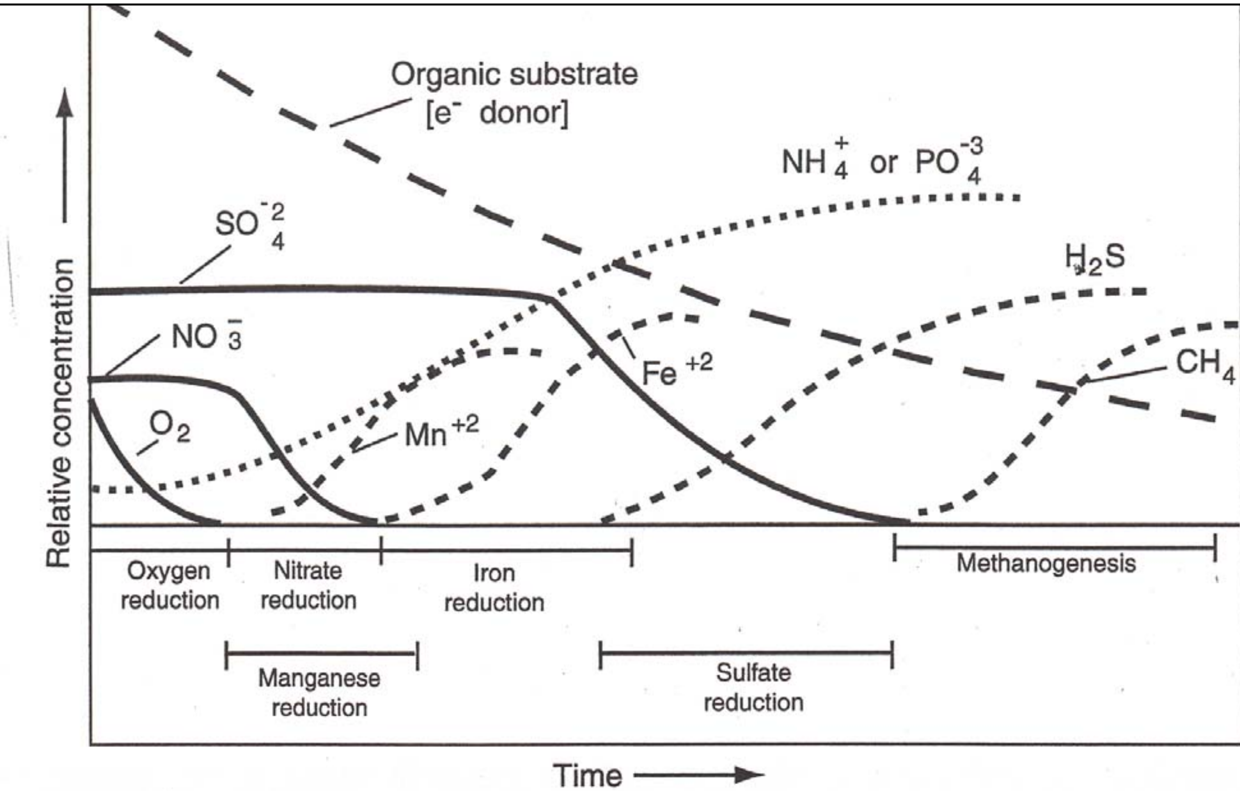

Figure 6-6 Sequence in time of transformations in soil after flooding, beginning with oxygen depletion and followed by nitrate and then sulfate reduction. Increases are seen in reduced manganese (manganous), reduced iron (ferrous), hydrogen sulfide, and methane. Note the gradual decrease in organic substrate (electron donor) and increases in available ammonium (NH_4^+) and phosphate (PO_4^{3-}) ions. The graph can also be interpreted as relative concentrations with depth in wetland soils. (*After Reddy and D'Angelo, 1994*)

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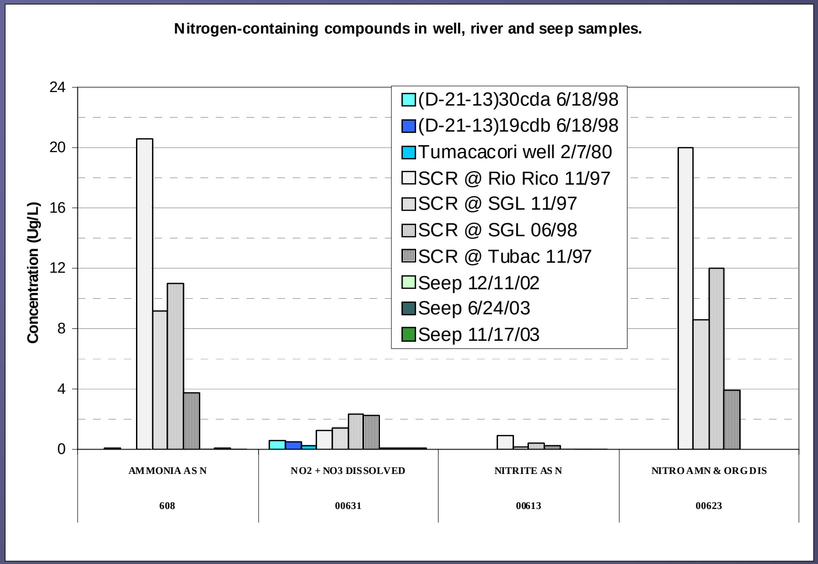
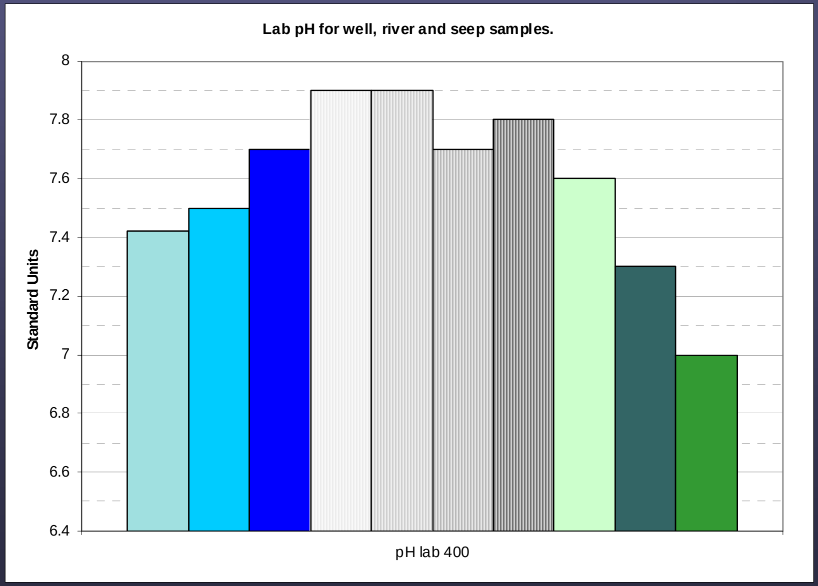
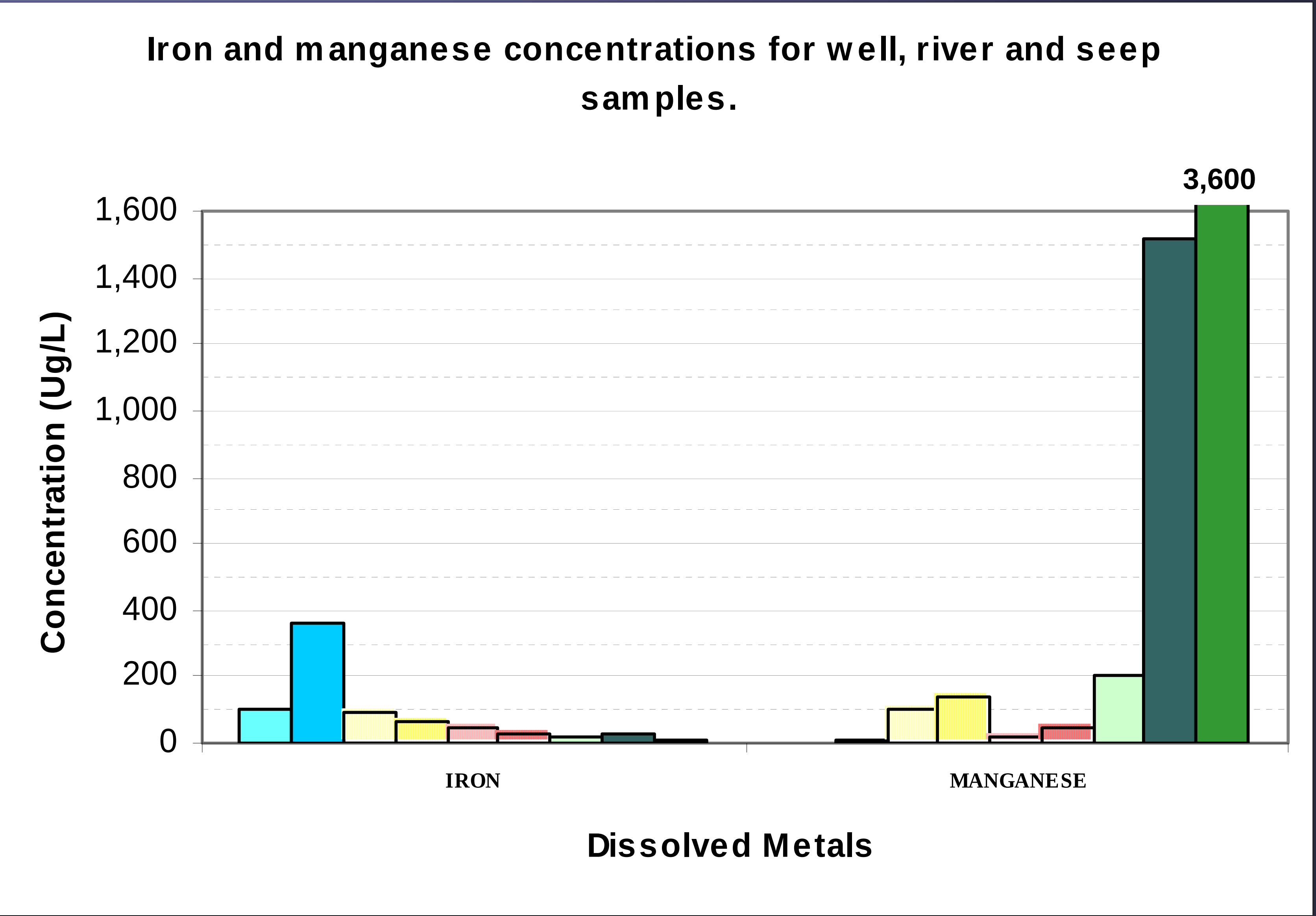


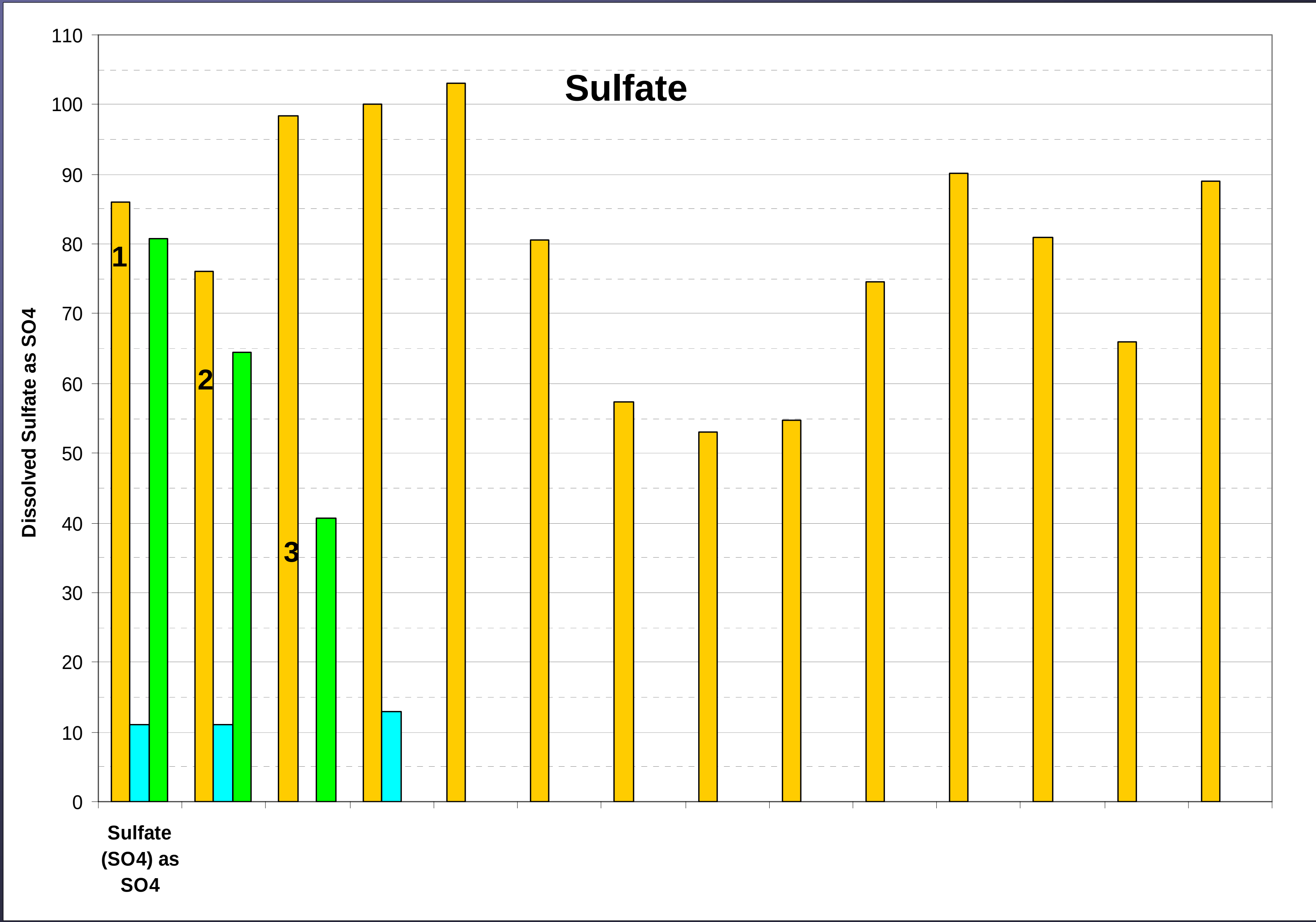
Nitrogen compounds



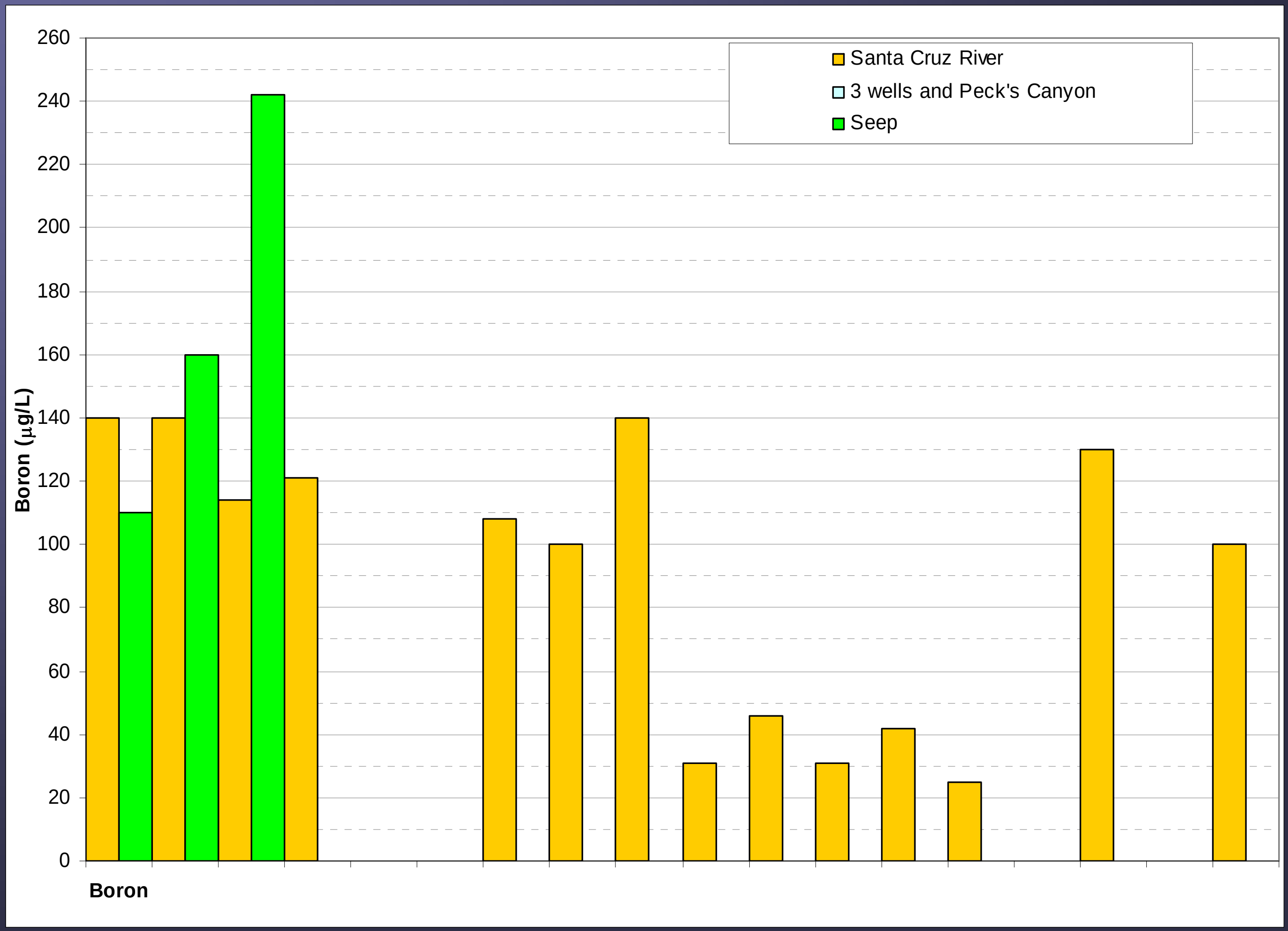
pH

C:\Colleen\1-Projects\TUMA\[TUMA Seep WQ Plt 6-7.xls]Data


Iron and manganese concentrations for well, river and seep samples.
3,600
1,600
1,400
1,200
1,000
800
600
400
200
0
Concentration (Ug/L)
IRON
MANGANESE
Dissolved Metals


Sulfate
Dissolved Sulfate as SO4
110
100
90
80
70
60
50
40
30
20
10
0
1
2
3
Sulfate (SO4) as SO4

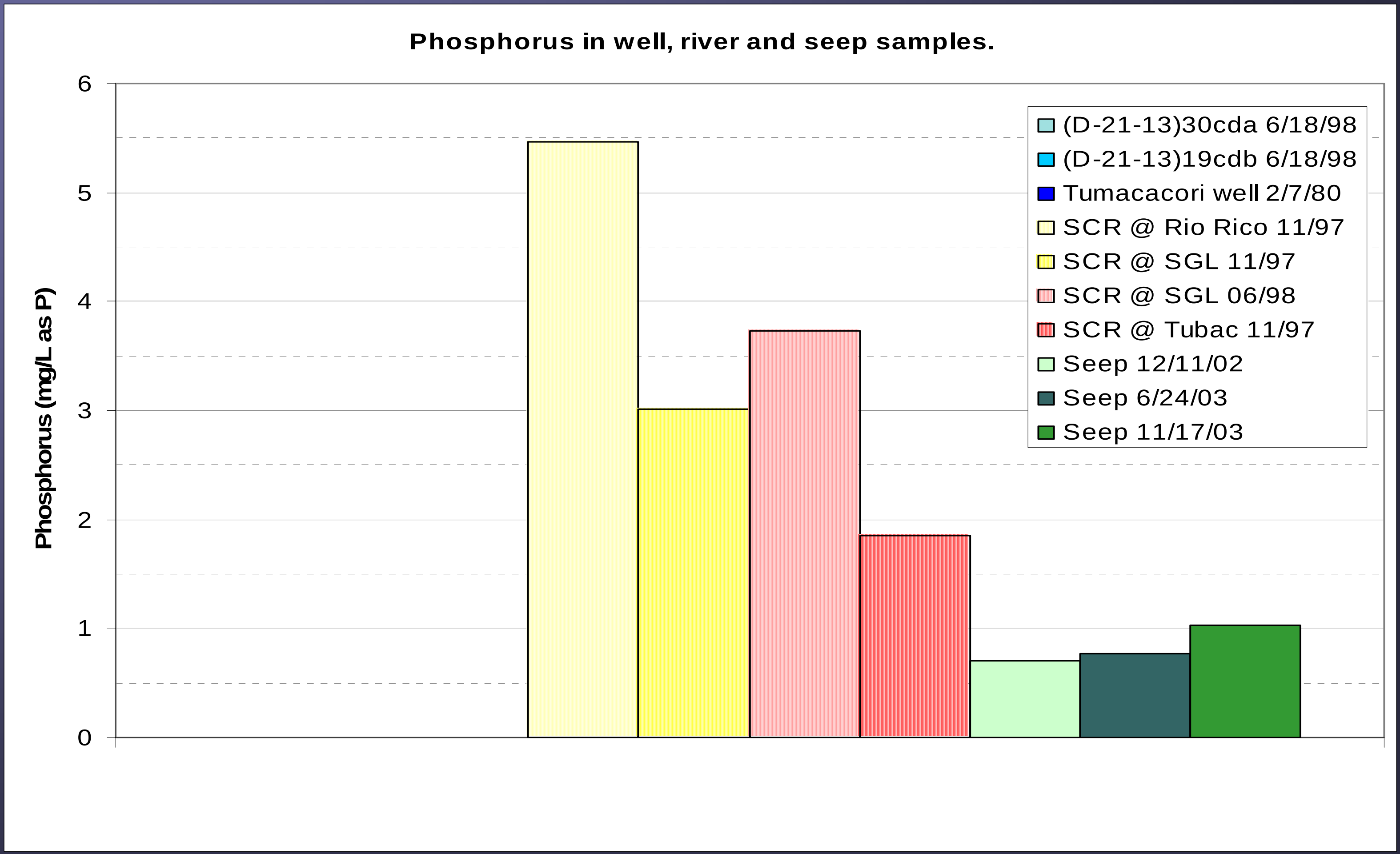
Boron



Santa Cruz River
3 wells and Peck's Canyon
Seep
Boron (µg/L)
260
240
220
200
180
160
140
120
100
80
60
40
20
0
Boron

#N/A

Phosphorus



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Conclusions: Redox Chemistry

-Sample 1 less reduced, but has experienced denitrification, cannot tell how far reducing conditions progressed

-Sample 2 still undergoing reduction of ferric compounds, sulfate reduction in early stages

-Sample 3 more advanced sulfate reduction has occurred

⇒Stagnant conditions – no substantial throughflow – no spring

⇒Tumacacori has a WETLAND…

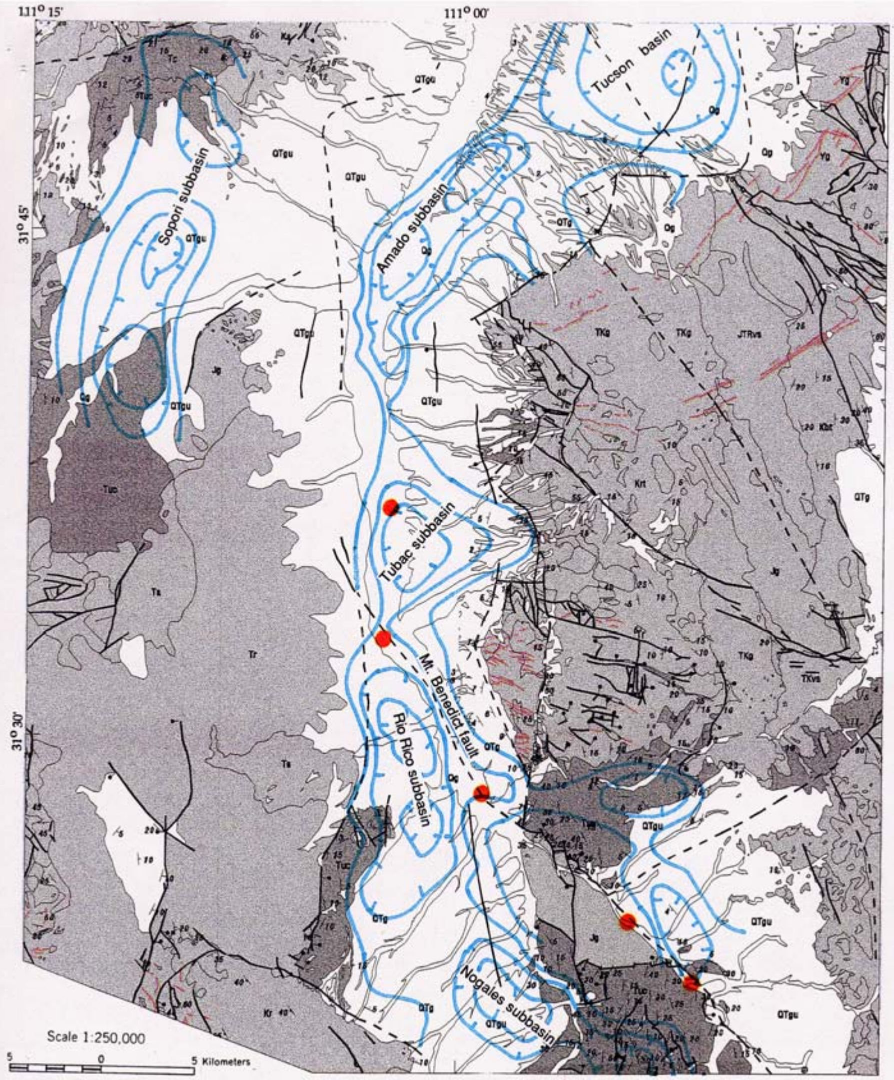


Figure 2. Generalized geologic map of the upper Santa Cruz Valley showing approximate location of subbasins based on complete Bouguer gravity anomaly map (plate 1). Gravity contour interval is schematic. Light shaded units are prebasin-fill rock; dark shaded unit is Nogales Formation; unshaded areas are upper basin fill and Quaternary alluvium. Orange dots indicate reaches of significantly higher gradient in the Santa Cruz River (table 1). Geology compiled by Drewes (1980) and modified by Houser (unpublished data).

7

4 subbasins:
- **-Nogales**
- **-Rio Rico**
- **-Tubac**
- **-Amado**

4 microbasins
- **-Buena Vista**
- **-Kino Springs**
- **-Highway 82**
- **-Guevavi**

Gettings and Houser, 1997

Conclusions

- **Seep chemistry is consistent with effluent source water modified by anaerobic soil chemistry processes**

- **Braided streambed created during higher flow events has persistent channels**
  - **Subgrade constriction (bedrock, clay lens) pushes groundwater to the surface – gaining reach**
  - **Similar seeps present all along the river channel (P. Halpenny)**
    - **North of Carmen, south of Tubac**
    - **Sonoita Creek outlet**
    - **Near the border at Buena Vista**
    - **Guevavi (Big Spring)**

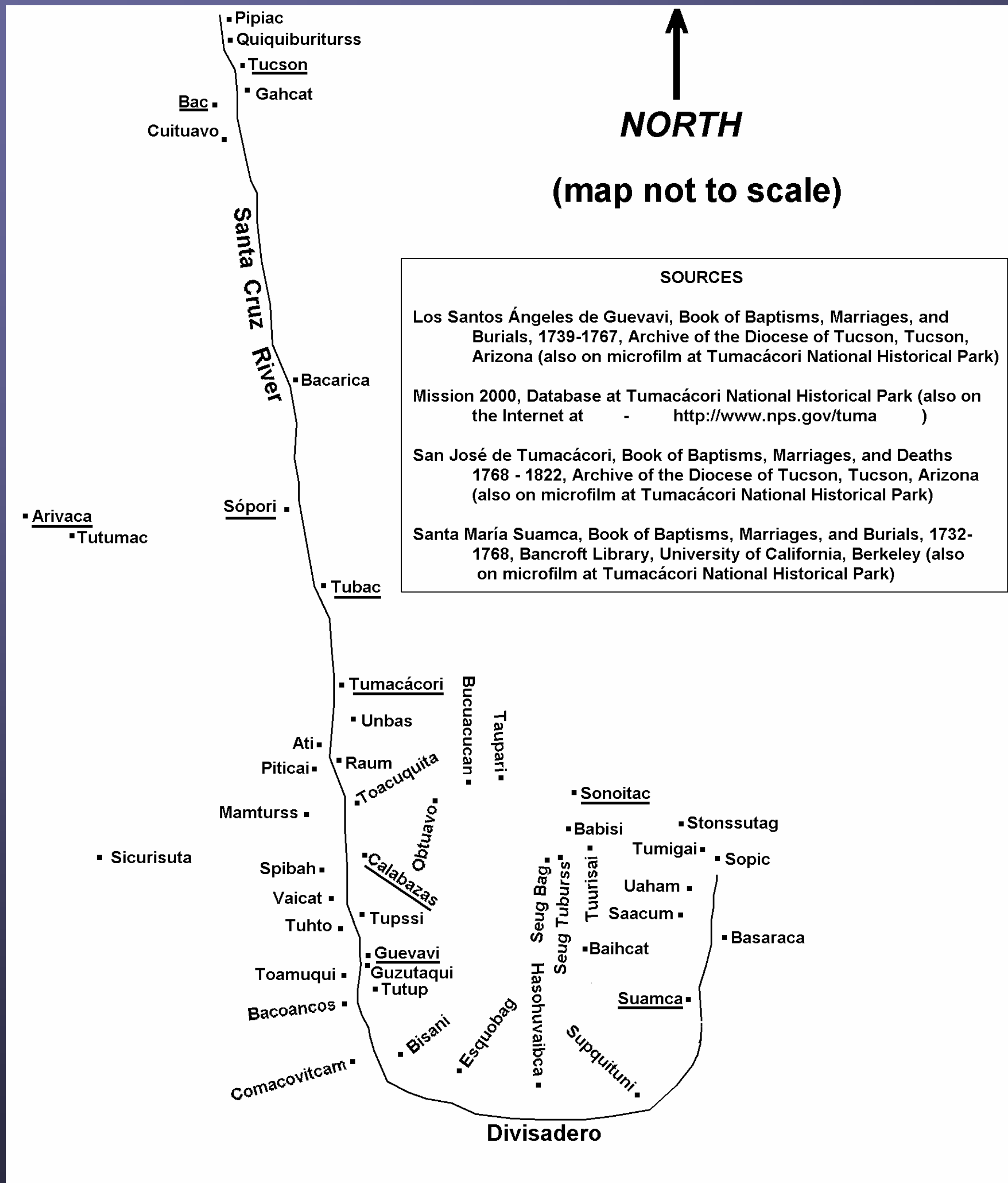
- **Groundwater subflow enters Santa Cruz River channel alluvium from tributaries including Peck Canyon, Josephine Canyon, and Sonoita Creek**

- **Without NIWWTP discharges, there would not be surface water at Tumacácori today**

- **Have wetland – cienega?**

Upper Santa Cruz River Basin

- Prehistoric-trade route
- O'odham settlements - rancherias
- Spanish presidios, missions and settlements; visitas
- Land grants (1790's to 1820's)
- Early – surface water diversions (acequias, zanjas)



Map of the O'odham Rancherias of the Upper Santa Cruz River Valley

Don Garate
Chief Interpreter and Historian
Tumacacori National Historical Park

1920 - 1940 – water table decline (Halpenny)

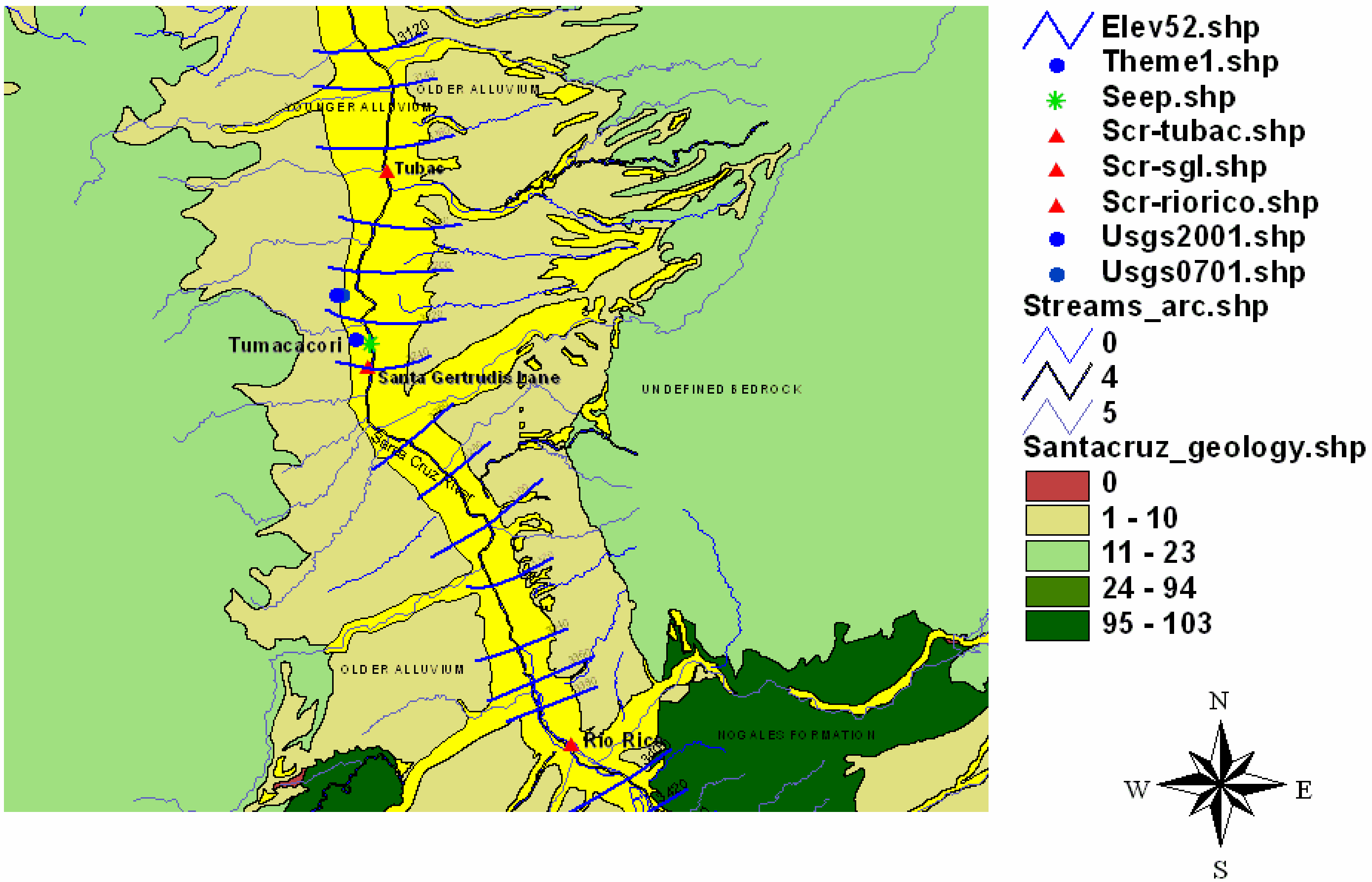
Riparian habitat disappeared by 1960

1972 effluent discharge begins NIWWTP

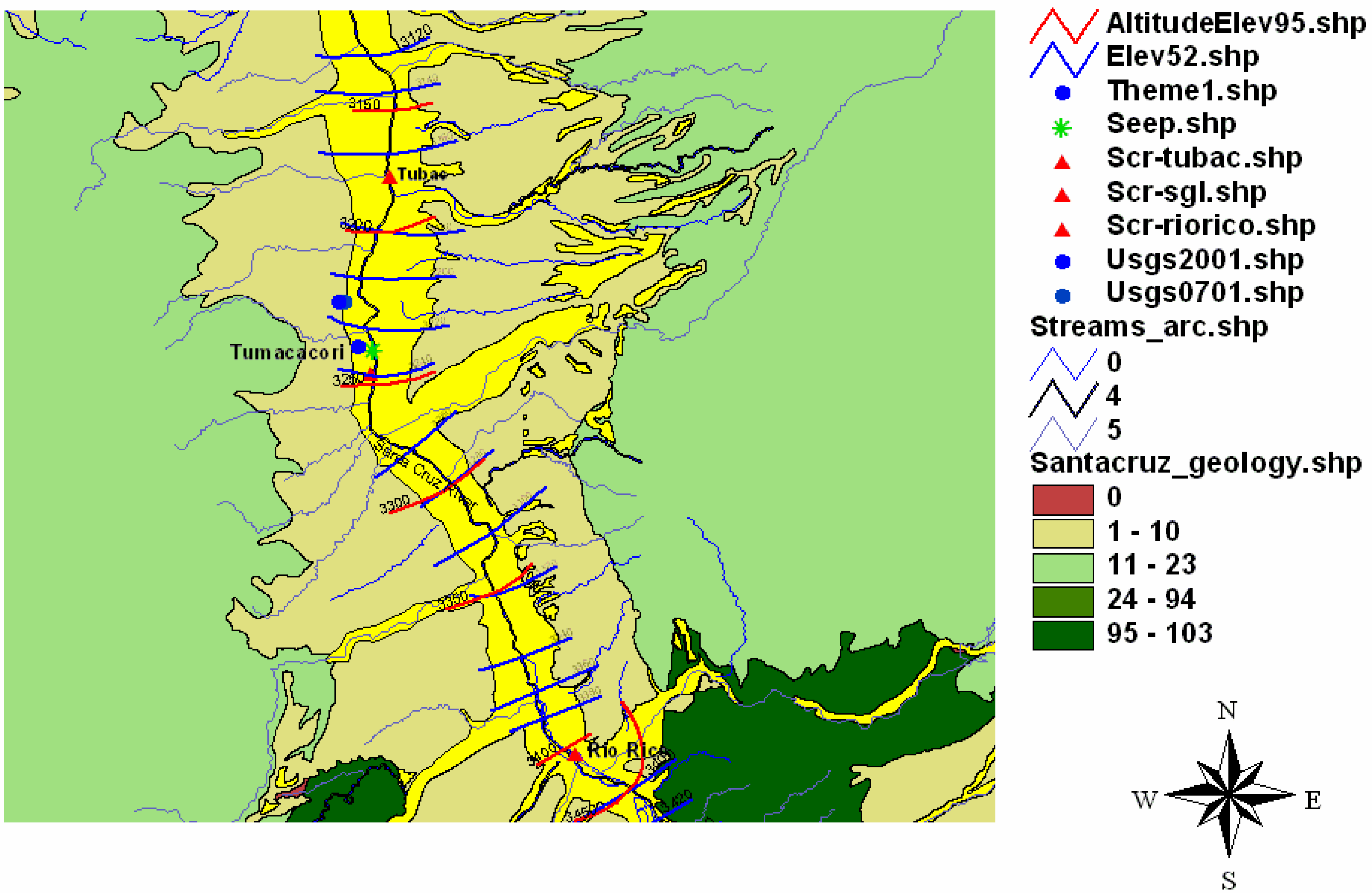
Perennial flow restored at Tumacácori in 1977

Future – increasing demand for water…

Water table contours 1952

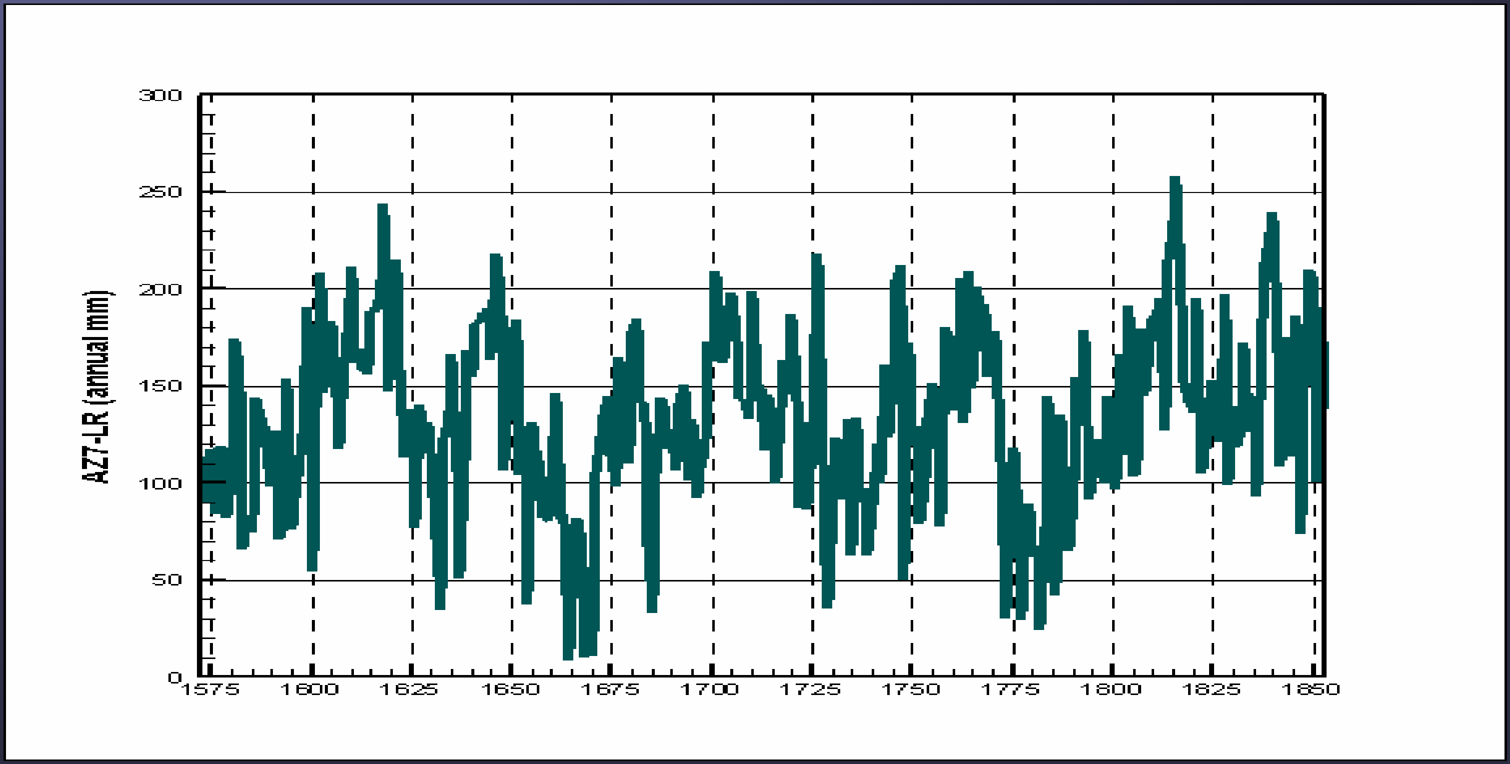


Water table contours 1952 and 1995



Future plans:

1. **Translate records dating to the Pima revolt (1751)**
2. **Search existing transcriptions from mission archives (Mission 2000)**
3. **Correlate events with reconstructed precipitation record**
4. **Improve maps relating to settlements, land grants and acequias**
5. **Develop interpretive materials**



Acknowledgements

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